

CHILDREN WITH DEVELOPMENTAL
PROBLEMS AND DISORDERS:
SELECTED ASPECTS OF MOTOR AND
MULTIDISCIPLINARY ASSESSMENT
AND INTERVENTION

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**Section of Physiotherapy Science
Department of Public Health and Primary Health Care
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University of Bergen
2006**



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If human beings are perceived as potentials rather than problems, as possessing strengths instead of weaknesses, as unlimited rather than dull and unresponsive, then they thrive and grow to their capabilities.

Bob Conklin

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ABSTRACT

The general aim of this thesis was to apply a multidisciplinary approach to selected clinical aspects of children with developmental problems and disorders, in order to contribute to the development of assessment and intervention strategies. Motor coordination difficulties were particularly focused. The following aspects were investigated in the separate studies:

- Behaviour, cognitive, linguistic and motor skills were assessed in 6-year old children considered at risk with regard to inclusion in ordinary schooling due to behavioural and emotional difficulties
- Incidence, severity and types of motor coordination difficulties in 6-year-old children with behavioural and emotional difficulties were compared to age and gender matched controls
- Incidence, severity and types of motor coordination difficulties in a group of 10-12 year old children with dyslexia and a group consisting of teacher referred poor readers, were compared to a control group, which comprised teacher referred good readers
- A participatory multidisciplinary team approach was developed and implemented at school start at 27 schools in two regions in Norway in order to promote health and improve services for all children, but with a particular focus on children with developmental problems and disorders
- Mid-childhood effects of a high-intensity, task specific school-based intervention approach were compared with traditional municipal physiotherapy intervention for 6-year old children with motor coordination difficulties.

The results from the evaluation of the 6-year-old children considered at risk with respect to ordinary school inclusion highlighted the importance of multidisciplinary assessment of young children with behavioural and emotional problems. While the most severe problems were found in social interaction and attention, the children also scored below average on cognitive and linguistic measures. Severe motor problems were found in more than half of the group. The following in-depth investigation of motor coordination difficulties revealed that 62.1 % in the high-risk group and 20.7 % in the control group showed borderline or definite motor coordination difficulties at or below the 15th centile when assessed with the Movement Assessment Battery for Children (M-ABC) (Henderson and Sugden, 1992). In the high-risk group 55.2 % fulfilled the criteria for developmental coordination disorder (DCD), compared to 3.4 % of the controls. The

high-risk group showed a mixed profile, with significant difficulties within all sub-areas of the M-ABC. Investigation of motor profiles for children in the high-risk group with specific types of behavioural and emotional problems showed a significant relationship between attention problems and manual dexterity difficulties, and continuous, precise fine motor movements were particularly difficult.

More than 50 % of the children with dyslexia as well as the group comprising teacher referred poor readers showed definite motor coordination difficulties at or below the 5th centile, compared to 13.6 % of the controls. Children in both groups performed significantly worse than controls within the sub-area of manual dexterity and balance, but not in ball-skills. Continuous precise fine motor movements stood out as particularly difficult for both groups of poor readers.

The participatory multidisciplinary team approach implemented at school start was reported to improve multidisciplinary teamwork and professional relations. An increased focus on general developmental and health care issues was also reported, as well as improved health and educational services to vulnerable children, including children with developmental problems and disorders. Local creativity and ownership within supportive administrative structures were evaluated as promoting factors, while available time and professional resources from the supportive municipal services stood out as main constraints. The construction of learning partnerships based on face-to-face interaction appeared to be a particular strength of the approach.

The evaluation of possible mid-childhood effects of two different types of intervention approaches applied at the age of six for children with motor coordination difficulties (DCD), revealed no significant differences with respect to total impairment and subscale scores at the M-ABC. At the levels of activity and participation the parents representing the high-intensity, task specific approach reported an overall more favourable situation. Their children were physically active, with frequent use of targeted motor skills learned during intervention. The majority of children from both groups displayed comorbid learning difficulties and attention deficits at follow-up, and the parents considered their children vulnerable and worried about future social functioning.

The studies demonstrated that children with developmental problems and disorders represent a complex, variable and vulnerable group. Although some pure cases of developmental disorders were identified, the majority of children evaluated presented with concomitant difficulties, highlighting a need for coordinated municipal multidisciplinary health and educational services.

ABBREVIATIONS

ABD	Atypical Brain Development
ADHD	Attention Deficit Hyperactivity Disorder
APA	American Psychiatric Association
BOTMP	Bruininks-Oseretski test of Motor Proficiency
C-MABC	Checklist of the Movement Assessment Battery for Children
CO-OP	Cognitive Orientation to Occupational Performance
DAMP	Deficits in Attention, Motor control and Perception
DCD	Developmental Coordination Disorder
DCD-Q	The DCD Questionnaire
DSM	Diagnostic and Statistical Manual of Mental Disorders
ICD	International Classification of Disease
ICF	International Classification of Functioning, Disability and Health
ITPA	The Illinois Test of Psycholinguistic Abilities
M-ABC	Movement Assessment Battery for Children
MND	Minor Neurological Dysfunction
NDD	Neuro Developmental Dysfunction
NTT	Neuromotor Task Training
PAR	Participatory Action Research
PLA	Participatory Learning and Action
RD	Reading Disorder
SPSS	Statistical Package for the Social Sciences
TOMI	Test of Motor Impairment
TRF	Teachers's Report Form
WHO	World Health Organization
WISC-R	The Wechsler's Intelligence Scale for Children – Revised

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LIST OF PAPERS

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1. INTRODUCTION

Growing up in today's rapidly changing society presents many challenges. Technological, economical and cultural developments put great demands on social, educational and political structures, as well as on the resources of each individual. Some children are more vulnerable than others when it comes to dealing with these challenges. This thesis focuses primarily on children with developmental problems and disorders, and addresses the presence of motor coordination difficulties in particular: how to identify and assess these problems, and how to develop and evaluate intervention strategies on an individual basis as well as at organizational levels within the children's municipal health and educational services in Norway.

Starting school is an important change in all children's life, and described as a key life transition involving children, their families and local communities (Dockett & Perry, 2001). The thesis focuses on children with motor and associated difficulties during this transitional period. Co-occurrence of motor coordination difficulties and reading problems in mid-childhood is also addressed, as well as mid-childhood effects of motor intervention at the age of 5-6 years.

The development of normal motor function requires coordinated neurological and physiological processes, including balance, strength, muscular co-activation, proprioception, dexterity, perceptual integration, and vision and visuo-motor abilities. Psychological aspects such as cognition, executive function and motivation also play a crucial role, as well as physical and emotional environmental factors (Campbell, 2000; Carr & Shepard, 1998; Shumway-Cook & Wollocott, 1995). Motor development is closely linked to motor learning (Campbell, 2000; Larin, 2000). Research from the field of motor learning has highlighted the interaction between the various individual processes, aspects of the task to be learnt and factors regarding the learning environment (Carr & Shepard, 1998; Magill, 2001; Shumway-Cook & Wollocott, 1995).

In view of the multiple factors involved in children's motor development and learning, it is hardly surprising that the aetiology of motor coordination difficulties is complex and unclear (Cermak, Gubbay & Larkin, 2002). A number of theories have been proposed, including motor planning difficulties (dyspraxia), difficulties in executing motor skills, various types of perceptual processing difficulties and automatization difficulties (e.g. Cermak et al., 2002; Nicolson, Fawcett & Dean, 2001; Sigmundsson, Hansen & Talcott, 2003; Smyth & Mason, 1997; Visser, 2003; Wilson & McKenzie, 1998).

1.1. Terminology

Historically, a number of terms have been used in order to describe children with motor coordination difficulties (Henderson & Barnett, 1998; Missiuna & Polatajko, 1995). In the mid-seventies the term “clumsy child syndrome” was used in order to describe children of normal intelligence and without identifiable medical or neurological conditions who had difficulties in coordination that interfered with academic performance and/or socialization (Gubbay, 1975). The third, revised edition of the “Diagnostic and Statistical Manual of Mental Disorders” (DSM-III-R; American Psychiatric Association (APA), 1987) included for the first time a separate entry for children with developmental motor coordination problems. A few years later, the World Health Organization established a comparable entry in their “International Classification of Disease”, using the term “specific developmental disorder of motor function” (ICD-10, World Health Organization (WHO), 1992). At a consensus conference in 1994, researchers agreed to use the term “Developmental Coordination Disorder” (DCD) from the DSM-IV (APA, 1994) classification system (Polatajko, Fox & Missiuna, 1995). According to the DSM-IV criteria, children must present with motor function significantly below chronological age (criterion A). The motor impairment must interfere significantly with activities of daily living (criterion B), and must not be related to a medical condition (criterion C). Criterion D states that the label DCD may be used in cases of mental retardation when the motor problems are in excess of those usually seen. However, researchers have reported that several of the criteria of DCD in the DSM-IV (APA, 1994) are difficult to operationalise (Cermak et al., 2002; Dewey & Wilson, 2001; Henderson & Barnett, 1998). Geuze, Jongmans, Schoemaker and Smits-Engelsman (2001) conducted an extensive review of studies on DCD, and showed considerable variability in procedures of operationalisation and reports about how the diagnostic criteria of the DSM-IV had been met. According to the DSM-IV – Text Revision the prevalence of DCD is 6% for children in the range of 5-11 years (APA, 2000).

1.2. Clinical features

Problems at all levels of the WHO’s International Classification of Functioning, Disabilities and Health (ICF) (WHO, 2001) have been reported for children with DCD. At the level of body function and structure, reviews have shown a wide variety of difficulties (for overviews see Cermak et al., 2002; Dewey & Wilson, 2001; Sugden & Wright, 1998; Visser, 2003). However, some primary impairment seems to be quite common. Children with DCD tend to present with a general slowness of movement (Henderson, Rose & Henderson, 1992; Missiuna, 1994; Rösblad

& von Hofsten, 1994). In a review concerning DCD and information processing, Wilson and McKenzie (1998) summarized a mild generalized performance deficit, as well as pointing to visual-spatial, kinaesthetic and cross-modal processing as the more pronounced areas of deficiencies. Decreased power and strength have also been reported (O'Beirne, Larkin & Cable, 1994; Raynor, 2001). At an activity level, the children often find activities such as running, jumping, climbing, riding a bike, swimming and ball-games difficult, as well as activities such as dressing, writing and using various tools (Cermak et al., 2002; Sugden & Wright, 1998). At a participation level, anxiety, lack of motivation and less participation in organized and recreational play activities has been reported (Hay & Missiuna, 1998; Losse et al., 1991; Rodger & Mandich, 2005; Schoemaker & Kalverboer, 1994; Skinner & Piek, 2001; Smyth & Anderson, 2000, 2001). However, as pointed out by Smyth and Anderson (2001) in their study of children with motor difficulties and football participation, there is considerable variability with regard to social inclusion and participation in socially valued team-games within groups of children with DCD.

1.3. Associated conditions

The group of children meeting the DSM-IV criteria of DCD is diversified and heterogeneous (Dewey & Wilson, 2001; Gillberg, 1998; Sugden & Wright, 1998). In reviews of intragroup analyses of children with DCD, Dewey (2002) and Visser (2003) concluded that the attempts to classify children with DCD into discrete subtypes have been met with limited success.

Longitudinal studies have shown that motor control problems are comorbid with Attention Deficit Hyperactivity Disorder (ADHD), as well as speech-language deficits, specific learning disorders, perceptual abnormalities and behavioural and psychiatric disorders (Cantell, Smyth & Ahonen, 1994, 2003; Gillberg, Carlström, Rasmussen & Waldström, 1983; Gillberg, Gillberg & Groth, 1989; Hellgren, Gillberg, Bågenholm & Gillberg, 1994; Kadesjö & Gillberg, 1998; Losse et al., 1991; Rasmussen & Gillberg, 2000). This frequent comorbidity led Gillberg et al. (1983) to suggest the diagnostic concept Deficits in Attention, Motor control and Perception (DAMP), which incorporates the overlap between DCD and ADHD. Kadesjö and Gillberg (1998) reported that about half of the 7-year-old children meeting all criteria for ADHD also met the criteria for DCD. Other studies of children with ADHD have confirmed the frequent overlap with motor coordination problems (Barkley, 1997; Harvey & Reid, 2003; Landgren, Kjellman & Gillberg, 1998; Piek, Pitcher & Hay, 1999; Pereira, Landgren, Gillberg & Forsberg, 2001; Pitcher, Piek & Barret, 2002; Slaats-Willemse, de Sonneville, Swaab-Barneweld & Buitelaar, 2005; Tervo, Azuma, Fogas & Fiechtner, 2002). Children with this particular combination are reported to have

more problems in their everyday life than children with ADHD only (Tervo et al., 2002). In their study of two groups of children with ADHD with motor difficulties and ADHD only, Tervo et al. (2002) observed that parents and teachers of the first group reported more pronounced social problems, thought problems, attention problems and total problems than the second group. Piek et al. (1999) reported that the type and degree of movement difficulties differed between ADHD subgroups. The inattentive subtype group in their study had significantly poorer fine motor skills compared to a combined subtype (inattentive and hyperactive) and controls, while the combined group displayed greater difficulty with gross motor skills. Kalff et al. (2005) showed that motor fluency and flexibility problems could be detected in 5-6 year old children later diagnosed with ADHD, indicating that such disturbances can be considered a basic impairment in ADHD. In his well-established model for ADHD, Barkley (1997) states that complex, goal-directed motor responses is under the control of four executive function domains that are linked to behavioural inhibition. Thus, problems concerning performance of complex movements indicate delayed development of motor inhibition (Barkley, 1997). However, as highlighted by Harvey and Reid (2003) and Pereira et al. (2001), not all children with ADHD seem to have motor difficulties, which complicates the picture, and points to a multifactorial background, involving deficits in higher as well as lower order motor control. Pereira et al. (2001) investigated the precision grip in a group of boys with DCD only and a group with DCD and additional ADHD. Compared to controls both study groups showed disturbances of basic coordination of forces in the initial phase of movement, with longer time latencies and higher force levels than the controls. The complex picture is supported by research from Mangeot et al. (2001), who reported substantial variability of sensory modulation dysfunction among children with ADHD.

Co-occurrence of attention deficits, learning difficulties and motor coordination problems has been reported in several studies over the years (e.g. Dewey, Kaplan, Crawford & Wilson, 2002; Kadesjö & Gillberg, 1998; Kaplan, Wilson, Dewey & Crawford, 1998; Ramus, Pidgeon & Frith, 2003). Kaplan et al. (1998) assessed motor function in a large sample of children referred due to learning and attention problems. An extensive motor evaluation was conducted, using a combination of Bruininks-Oseretski test of Motor Proficiency (BOTMP) (Bruininks, 1978), M-ABC and the DCD Questionnaire (DCD-Q) (Wilson, Dewey & Campbell, 1998). Within this sample they found high prevalence of DCD compared to normal controls, and a major overlap between reading disorder (RD), ADHD and DCD. From a different angle, but using the same measures of motor function as Kaplan et al. (1998), Dewey and colleagues (2002) investigated problems of attention, learning and psychosocial problems evidenced by a group of children with DCD, children with suspected DCD and controls. Results revealed that both children with DCD

and suspected DCD obtained significantly poorer scores on measures of attention and learning (reading, writing and spelling). O'Hare and Kalid (2002) also reported a high risk of reading and writing delay in children with DCD.

In a series of research within the field of dyslexia, the research from Nicolson, Fawcett and collaborators point to motor problems and abnormalities in muscle tone as common symptoms in the majority of dyslexic children (Fawcett & Nicolson, 1992, 1999; Nicolson & Fawcett, 1990, 1994, 1999). They interpreted their findings as supporting the automatization deficit hypothesis of dyslexia. According to their findings the cerebellum plays an important role in this type of deficit (Fawcett, Nicolson & Dean, 1996; Nicolson et al., 2001). This has been supported by neuroanatomical and neuroimaging findings (Nicolson et al., 1999; Rae et al. 1998, 2002). However, other researchers have failed to replicate these findings. While Yap and van der Leij (1994) reported a partial replication, other attempts have been unsuccessful (van Daal & van der Leij, 1999; Kronbichler, Hutzler & Wimmer, 2002). Wimmer, Mayringer and Raberger (1999) reported that balance problems disappeared when dyslexic children with additional ADHD symptoms were excluded from the sample. Raberger and Wimmer (2003) further investigated the relationship between reading disability and ADHD to balancing problems. Results indicated that poor balancing (both as single and dual-task) was found to be unassociated with RD, but with ADHD. Ramus et al. (2003) found motor difficulties in postural stability, bead threading and the finger to thumb tasks in about half of a group of English dyslexic children. They concluded that while their study supports the presence of motor difficulties in many children with dyslexia, comorbid disabilities such as ADHD and DCD might be the main explanation for these difficulties.

As a consequence of the ambiguities and difficulties of classification of the various specific learning disorders, Bax (1999) suggested the term "Neurodevelopmental Dysfunction" (NDD) as a superior term, emphasizing the role of the central nervous system as well as developmental aspects in these problems. Based on studies of comorbidities evidenced by children with DCD or suspected DCD, Kaplan et al. (1998) introduced the term "Atypical Brain Development" (ABD) as a unifying concept that describes developmental variations in the brain. Children with ABD may display a variety of symptoms, depending on their specific profile of brain-based strengths and weaknesses (Dewey et al., 2002).

Applying the slightly different, but related concept of minor neurological dysfunctions (MND), Hadders-Algra (2002) highlighted a growing awareness of the age-dependency of MND, as developmental time often is needed before minor dysfunctions can be expressed by the

increasing complexity of the nervous system. Follow-up of 3-year birth cohorts from the University Hospital in Groningen at school age revealed increasing signs of MND with at peak shortly before the onset of puberty, then followed by a decline in the rate, possibly mediated by hormonal changes (Lunsing, Hadders-Algra, Huisjes & Touwen, 1992; Soorani-Lunsing, Hadders-Algra, Olinga, Huisjes & Touwen, 1993). However, both before and after the onset of puberty, two distinct categories of MND were found that were characterized by Hadders-Algra (2002) as simple and complex MND. For the complex type, pronounced fine motor difficulties and coordination problems were found at 14 years of age, as well as cognitive and attention problems, thus resembling Kadesjö and Gillbergs's (1998) description of children with DAMP. While the prognosis for children with simple MND seems fairly good, children with complex MND are in great need of support and intervention (Hadders-Algra, 2002).

1.4. Prognosis

In line with the findings from the longitudinal research presented by Hadders-Algra (2002), there is evidence that motor problems persist into adolescence for a large group of children with DCD (Cantell et al., 1994; Christiansen, 2000; Geuze & Börger, 1993; Losse et al., 1991). Interestingly, and in line with the longitudinal findings from the Netherlands (Hadders-Algra 2002), at follow-up of clumsy 5-year-olds at the age of 17-18, Cantell et al. (2003) found evidence for two distinct pathways for developmental coordination disorder. The adolescents in the DCD group with severe perceptual motor problems at the age of 15 years (Cantell et al., 1994) still displayed significant difficulties, while the intermediate group, which had shown only minor signs of perceptual motor dysfunction at the age of 15, now performed close to the level of the control group. In a study of adults with a history of DCD aged between 18 and 65 years, Cousins and Smyth (2003) found that the DCD group still performed more poorly than controls on a wide range of motor skills. In their follow-up of natural outcome for ADHD with DCD at the age of 22 years, Rasmussen and Gillberg (2000) showed that the combination of childhood ADHD and DCD (severe DAMP) appeared to be an important predictor of poor psychosocial outcome in early adulthood. They concluded that DCD is a possible marker for a whole range of developmental disorders, and strongly recommended early identification and intervention.

1.5. Identification and assessment

As pointed to by Wilson (2005), the fact that comorbidity seems to be the rule rather than the exception for children with developmental difficulties highlights the importance of multi-modal

assessment. Identification and evaluation of motor coordination difficulties should be undertaken within such a framework. The increased awareness regarding children with motor coordination deficits has led to a search for reliable and valid assessment instruments suitable for application in kindergartens, schools and clinics. With regard to identification, several questionnaires have been developed, such as the Checklist of the Movement Assessment Battery for Children (C-MABC) (Henderson and Sugden, 1992) and the DCD-Q (Wilson et al., 1998). However, reliability and validity checks of these instruments have shown that teacher- as well as parental reports needs to be interpreted with care due to confounding variables such as teacher competence and comorbid conditions (Green et al., 2005; Junaid, Harris, Fulmer & Carswell, 2000; Piek & Edwards, 1997).

In his review of approaches to assessment and intervention for children with DCD, Wilson (2005) listed the M-ABC and the Bruininks-Osteretsky Test of Motor Proficiency (BOTMP) as by far the most commonly applied assessment tools. Both tests are descriptive, standardized and norm-referenced measures resulting in broad motor profiles. Another commonly applied type of measure is the Ayres Southern California Sensory Integration tests (Ayres, 1980, 1989), anchored in Sensory Integration Theory. Crawford, Wilson and Dewey (2001) points to the fact that none of the tests mentioned can be considered a “gold standard”. Difficulties concerning operationalisation of the diagnostic criteria of DCD may partly explain why this is so. According to the DSM-IV criteria the diagnosis of DCD includes evaluation of how the children’s motor problems affect daily living and academic achievement. As emphasized by Geuze et al. (2001) in their meta-analysis of studies concerning DCD, this criterion was frequently not addressed. Henderson and Barnett (1998) found it reasonable to assess whether a child’s motor difficulties significantly interfere with activities of daily living, but there are still no guidelines provided as to how this actually should be done. Henderson and Barnett (1998) also highlighted difficulties concerning the second part of this criterion, which states that the diagnosis “only should be made if the motor impairment significantly interferes with academic achievement”. In their opinion, this is very difficult to operationalise, and also undermines evidence supporting the importance of intervention on children’s movement difficulties in the early years.

With respect to criterion C, both diagnostic manuals underscore the exclusion of children with known neurological disorders. However, recent advances in brain imaging techniques have made it possible to detect small lesions as well as transitory brain affections, making it very difficult to draw distinct lines between “neurological conditions” and “specific motor

impairments”. There is also a blurred line between light cases of cerebral palsy and cases of severe developmental coordination disorder (Geuze et al., 2001).

Interpretation of criterion D is also problematic, as the relationship between mental retardation and motor function is not well established (Geuze et al. 2001; Henderson & Barnett, 1998). Geuze et al. (2001) concluded their review by recommending that the lower limit of IQ level should be set at 70.

1.6. Intervention

The high rate of co-existing problems in children with developmental deficits has important implications with regard to treatment, and calls for multidisciplinary competence and multi-modal intervention strategies (Gillberg et al., 2004; Wilson, 2005). Several approaches to intervention for motor coordination difficulties have been applied and evaluated. Historically, motor intervention focused on the improvement of underlying processing deficits, assuming a direct relationship between underlying processes and functional performance (Mandich, Polatajko, Macnab & Miller, 2001). However, more recent theories from the field of motor control and learning have challenged this relationship. As a result, intervention approaches that focus directly on skill acquisition, in the literature frequently referred to as “top-down” approaches, have increased (Larkin & Parker, 2002; Mandich et al., 2001; Niemeijer, Smits-Englesman, Reynders & Schoemaker, 2003; Wilson 2005).

Reviews of intervention studies conclude that evidence for the traditional general (or so-called “bottom-up”) approaches are lacking (Mandich et al. 2001; Pless & Carlsson, 2000; Sigmundsson, Pedersen, Whiting & Ingvaldsen, 1998; Wilson, 2005). With respect to specific skills approaches, these are relatively new, and empirical evidence is gradually beginning to accumulate. Revie and Larkin (1993) found support for a task-specific approach in their 9 week-intervention study of two groups of children with motor coordination problems acting as each other’s controls. The groups were taught two different sets of tasks with reported significant improvement in the tasks specifically trained. Evaluating a school-based intervention program, Wright and Sugden (1998) found evidence in support of the task-oriented cognitive-motor approach advocated in the M-ABC manual (Henderson & Sugden, 1992). Pless and Carlsson (2000) concluded their meta-analysis of intervention studies by pointing to specific skills approaches as more effective than the traditional approaches. They also investigated effects of general motor skill intervention in two groups of 5-6 year-old children with DCD, and concluded that although no significant differences were found with regard to total M-ABC scores, several

children in the experimental group with borderline difficulties scored within the normal area after intervention (Pless, Carlsson, Sundelin & Persson, 2000). Within a motor learning perspective, the DCD research group in Canada has developed a cognitive-motor approach to intervention (Cognitive Orientation to Occupational Performance or CO-OP) with positive effects reported (Miller, Polatajko, Missiuna, Mandich & Macnab, 2001; Polatajko, Mandich, Miller & Macnab, 2001). Within CO-OP, the development of movement skills is seen as a result of the active solving of movement problems under variable conditions, enhanced by the application of motor teaching strategies (Miller et al., 2001; Missiuna & Mandich, 2002). Another example of a recently developed specific skills approach is Neuromotor Task Training (NTT) (Niemeijer et al., 2003). NTT incorporates several principles derived from the field of motor control and learning, and a great deal of attention is directed towards the application of motor teaching principles. Finally, Wilson (2005) has described the Cognitive Neuroscientific Approach, a process-oriented treatment approach based on validated brain-behaviour models of motor control and learning. Improvement of deficits in internal modelling of movement and timing control are important aspects of the treatment approach, with pilot-studies showing promising effects on generalization across skills (Wilson, Thomas & Maruff, 2002; Wilson, 2005).

1.7. Increased vulnerability due to cultural factors

A new range of lifestyle induced health problems, with implications for motor function, is reported among a growing number of children and adolescents. A decrease in physical activity, often combined with an unhealthy diet are presented risk factors (Bloomgarden, 2004; Lindström, Isacson & Merlo, 2003; Rigby, Kumanyika & James, 2004), leading to an increase in obesity (Batch & Baur, 2005; Morill & Chinn, 2004; Van Staveren & Dale, 2004), and long term illnesses such as type 2 diabetes (Bloomgarden, 2004; Peters, 2004). Viewed from a motor learning perspective, children who are physically inactive and/or severely obese at an early age, have restricted opportunities of learning valuable motor and social skills, with possible long term negative effects on health and social function. Children with DCD and ADHD have been reported to be particularly at risk for poor levels of physical fitness (Harvey & Reid, 2003; Missiuna, Rivard & Bartlett, 2003).

1.8. A developmental perspective on vulnerable children

In order to promote health and thus prevent life style induced difficulties, establishing a healthy lifestyle at an early age is considered important (Bloomgarden, 2004; Van Staveren & Dale,

2004). Early identification and intervention is also of great importance for children who present various developmental disorders, as problems accelerate when the children grow older and are faced with increasing complexity and educational challenges (Hadders-Algra, 2002; Missiuna et al. 2003; Stormont, Espinosa, Knipping & McCathren, 2003).

When motor coordination difficulties are viewed in a developmental perspective, motor problems are often identified early, whereas learning problems, ADHD and other comorbid difficulties become gradually more evident (Hadders-Algra & Groothuis, 1999; Hadders-Algra, 2002, Kadesjö & Gillberg, 1998; Slaats-Willemse et al., 2005). It is therefore recommendable to try to identify these children early through systematic observation and monitoring of their motor problems (Fallang, Øien, Hellem, Saugstad & Hadders-Algra, 2005; Hadders-Algra & Groothuis, 1999; Missiuna et al., 2003). Early identification of motor problems increases opportunities regarding motor intervention, but could also be a marker for the possible occurrence of later additional developmental difficulties.

Viewing intervention procedures and approaches in a developmental perspective reveals that we currently lack information about long-term effects of early, motor skill intervention for children with motor coordination difficulties. In order to decide when, how and which resources should be invested, different types of intervention programs need to be further developed, implemented and evaluated (Larkin & Parker, 2002; Miller et al., 2001; Sugden & Wright, 1998; Wilson, 2005).

The presence of developmental delays and disabilities represents particular challenges regarding a child's transition to school. In Norway all children have a right by law to attend their local school and inclusion is advocated as educational ideology (UNESCO, 1994, 2003). In order to provide the best possible identification, assessment and intervention for these vulnerable children, the complexity of developmental problems and high rate of comorbidity of developmental disorders call for a multidisciplinary perspective. Our knowledge concerning prognosis and long-term difficulties add weight to the importance of early action. As such, much can possibly be gained by providing extra resources and a multidisciplinary focus at school start.

1.9. The purpose and aims of the present studies

The purpose of the present thesis was to apply a multidisciplinary approach to selected aspects of the clinical landscape for children with developmental problems and disorders, in order to contribute to the development of assessment and intervention strategies for this vulnerable and complex group. Motor coordination difficulties were particularly focused.

The specific aims were:

- To assess behaviour as well as cognitive, linguistic and motor skills and to correlate behaviour and skills in 6-year old children considered at risk with regard to inclusion in ordinary schooling (Paper I).
- To investigate incidence, severity and types of motor coordination difficulties in 6-year old children with severe behavioural and emotional problems (Paper II).
- To investigate incidence, severity and types of motor coordination difficulties in 10-12 year old children with reading problems (Paper III).
- To provide general health promotion and early intervention for children with developmental disorders and other types of vulnerabilities by investing and re-directing community health and educational resources at school start (Paper IV).
- To develop and evaluate how a participatory multidisciplinary team-approach applied at school start may enhance professional competence with regard to children with developmental disorders and other types of vulnerabilities (Paper IV).
- To develop and investigate motor and multidisciplinary intervention strategies for children with motor coordination difficulties and associated problems at school start (Paper IV and V).
- To evaluate mid-childhood effects of a high-intensity, task specific school-based intervention approach compared with traditional municipal physiotherapy intervention for 6-year-old children with motor coordination difficulties (Paper V).

2. MATERIALS AND METHODS

As described above, a multidisciplinary approach to children with developmental problems and disorders is at the heart of the thesis, encompassing as it does several studies with different purposes. Hence, the methods and research designs included represent a variety, from standardized instruments to qualitative and flexible evaluative approaches, from measurement of co-occurrence of motor, emotional and psycholinguistic problems to health promotion for 6-year olds at school start through a participatory action research design. In the following, an overview of aims and participants of the particular studies are presented, and the different methods are outlined.

2.1. Overview of aims and participants of the particular studies

2.1.1. Paper I

Assessment of behaviour as well as cognitive, linguistic and motor skills in 6-year-old children considered to be at risk with regard to inclusion in ordinary schooling was accomplished in this study. A total of 31 6-year-old children (4 girls, 27 boys, mean age 75.94 months) enrolled in a one-year high-risk programme in a city in Norway, preparing them for ordinary schooling participated. Based on clinical findings of frequent comorbidity between behavioural and other developmental difficulties within the cognitive, linguistic and motor domain, teachers had developed a programme consisting of intensive daily training of cognitive, social and motor skills. The children were referred to the programme by careful selection from the municipal school psychology service, and the main criteria for inclusion were persisting behavioural and emotional problems.

2.1.2. Paper II

The study focused on the co-occurrence of behavioural and emotional problems and motor coordination difficulties. In this study incidence, severity and types of motor coordination difficulties were assessed, and children fulfilling the formal diagnosis of DCD according to the DSM-IV (APA 1994) criteria were identified. Twenty-nine children (4 girls, 25 boys, mean age 6.35 years) from the high-risk group from Study I were compared with 29 age- and gender matched controls (mean age 6.17 years) randomly drawn from a total sample of 83 first grade children, who had been tested with the M-ABC as part of collection of Norwegian normative data

for the test. Normative data were collected from two first grade groups at typical all-inclusive schools in a middle-sized Norwegian town.

2.1.3. Paper III

Incidence, severity and types of motor coordination difficulties in poor readers were studied. Two groups of poor readers aged 10-12 years participated. The first group comprised 20 children (17 boys, 3 girls), with a mean age of 11 years 1 month, who over a period of 14 months were referred to a regional Competence Centre in Norway due to severe reading problems. The second group consisted of 17 children (11 boys, 6 girls) with a mean age of 10 years 6 months identified as poor readers in a Norwegian municipality with 14 000 inhabitants. There were about 200 pupils at each grade level. Teachers of children in grade 6 (corresponding to 10-11 years) were asked to select the poorest 5% of readers from their classes. Such sampling provided a cross-section of poor readers, because the poor readers were selected on the basis of their overall reading difficulties rather than by the presence of a particular type of reading deficit. The two groups were compared with a control group selected by the teachers as the 5 % best readers. The control group comprised 22 children (7 boys, 15 girls) with a mean age of 10 years 5 months.

2.1.4. Paper IV

The study comprised two large-scale action research projects. External professionals from the supportive municipal health care system and special education/school psychology services assisted children and teachers in the first grade, focusing on early health promotion and support to children at risk for developing problems. A participatory multidisciplinary on-site team approach was developed, with local teams established at each school. The projects aimed at providing early multidisciplinary evaluation and intervention for children with developmental problems and disorders, as well as increasing teacher competence with regard to health issues in general and vulnerable children in particular. The approach was implemented at school start at 27 schools in two different geographical regions in Norway over a three-year-period. Ten schools were located in three city-districts in Stavanger, while 17 schools were located in the municipalities of Bø, Hadsel, Sortland, Lødingen and Øksnes in the region Vesterålen and Lødingen. Total number of children included was about 1500.

Figure 1 gives an overview of the participants:

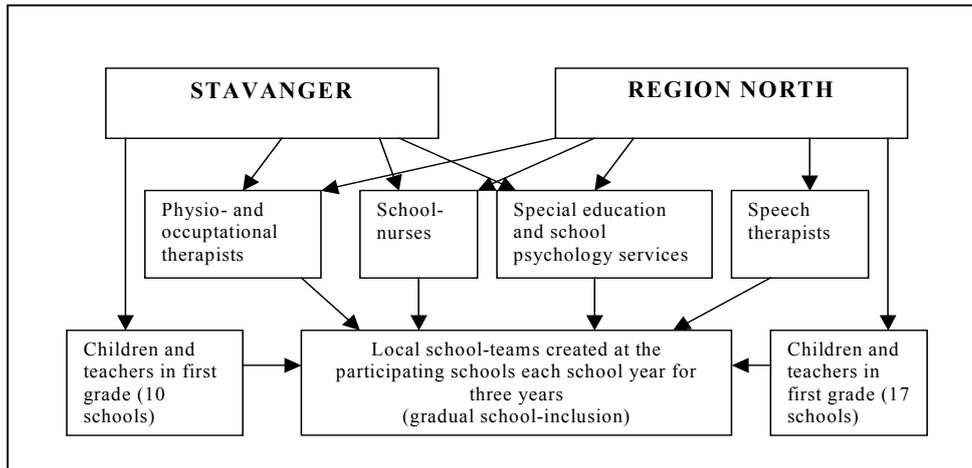


Figure 1: Overview of participating groups in Stavanger and Region North

2.1.5. Paper V

In this study, possible effects of motor intervention applied at the age of 6 were compared in mid-childhood. The children’s motor function as well as parental perspectives was evaluated based on the functional levels of the International Classification of Functioning, Disability and Health (ICF) (WHO, 2001). The study comprised two groups of children who at the age of 6 years displayed definite motor coordination difficulties and at that time received two various types of intervention. One group of 15 children (2 girls, 13 boys, mean age 8 years 4 months at follow-up) had received a high-intensity task specific intervention approach at a daily basis at school for one school-year, while the other group of 15 children (2 girls, 13 boys, mean age 8 years 8 months at follow-up) had received traditional weekly physiotherapy group intervention, administered by the municipal health services.

2.2. Methods

2.2.1. The Movement Assessment Battery for Children (M-ABC)

The M-ABC is a comprehensive assessment battery consisting of the M-ABC Checklist, the M-ABC Test and a set of intervention guidelines. The test is an improved version of the earlier Test of Motor Impairment (TOMI) (Stott, Moyes & Henderson, 1984). The M-ABC Checklist focuses primarily on the assessment of movement problems at activity level in educational settings. The M-ABC test yields an overall motor impairment sum-score indicating increasingly pronounced motor difficulties with increasing scores. There are four age-bands covering 4-6, 7-8, 9-10 and 11-12 years. The test yields sub-scores for the areas manual dexterity, ball skills and balance as

well as sub-test scores within these areas. The test consists of 8 different test-items, yielding ordinal data scored from 0-5, with 5 indicating severe motor difficulties on the particular item and 0 indicating no problems. Items 1-3 measure manual dexterity: 1) speed and precision of each hand separately, 2) coordination of two hands performing a single task, 3) eye-hand coordination as required in the control of a pen. Items 4-5 measure ball skills: 4) accurately throwing an object, 5) catching an object. Items 6-8 measure different aspects of balance: 6) static balance, 7) fast and explosive movements, 8) slow and controlled movements.

The M-ABC has been standardized in the USA, and specific standardization of the test has not yet been carried out in Norway. Cross-cultural differences have been reported for Chinese children (Chow, Henderson & Barnett, 1998) and Japanese children (Miyahara et al., 1998). However, in her study of 360 9-10 year old children Mæland (1992) applied the TOMI-test and concluded that the norms were appropriate for Norwegian children. In a cross-cultural comparison of two matched groups of 6-year old American and Swedish children, Rösblad and Gard (1998) concluded that the norms were appropriate for Swedish children, thus adding support to the previous findings of Mæland (1992). In a study of Dutch children Smith-Engelsman, Henderson and Michels (1998) reported that the norms provided in the M-ABC manual seem to require relatively little alteration in Western Europe. Sigmundsson and Rostoft (2003) assessed 91 Norwegian 4-year-olds with the M-ABC, and in contrast to the M-ABC manual, which reported no significant differences between the sexes (Henderson & Sugden, 1992), they found significant differences in favour of the girls on three test-items (manual dexterity item 2 and 3, and the item static balance). As the M-ABC was the most important assessment tool in the papers of this thesis, a sample of 146 Norwegian children in first grade from two different geographical parts of Norway was assessed with the M-ABC in order to compare performance of Norwegian children in this particular age group to the norms provided in the manual. An overview of the findings is presented in the result section of the thesis.

The M-ABC test is extensively used as a clinical tool in Norway. According to the manual, overall reliability is good, ranging from 97 % agreement in 5-years-old children to 73 % in 9-years-old. Other studies support acceptable overall reliability (Chow & Henderson, 2003; Croce, Horvat & McCarthy, 2001). Because the M-ABC is a modification of the TOMI (Stott et al., 1984), Henderson and Sugden (1992) stated that the evidence supporting the sound psychometric properties of the TOMI could be generalized to the M-ABC.

The M-ABC was applied in Study I, II, III and V.

2.2.2. The Wechsler's Intelligence Scale for Children – Revised (WISC-R)

The Wechsler's Intelligence Scale for Children – Revised, WISC-R, (Wechsler, 1974) was used to assess the cognitive abilities of the children. The Norwegian version (Undheim, 1978) is standardized for the age band 6½ years to 15½ years, and was the most commonly used intelligence test in Norway until the WISC-III was released in 2003. The WISC-R consists of 12 subtests, six measuring verbal and six measuring non-verbal skills.

The WISC-R was applied in Study I, II, III and V.

2.2.3. Teachers's Report Form (TRF)

The Norwegian version of Teacher's Report Form, TRF, (Achenbach, 1991) was administered to obtain information about the children's behavioural patterns. The report is constructed to assess social competence and behavioural and emotional problems in children. Report forms developed for parents, teachers, and children themselves have been translated into 60 languages, and they are reported in more than 5000 publications worldwide (Achenbach, 2004). They are frequently used in clinical work in Norway (Øgrim & Gjørsum, 2002). The TRF is standardised for boys and girls between 5 and 18 years of age. The 120 items, covering various forms of deviant behaviour/emotional problems, are rated on a scale from 0 to 2 (0 = "not true", 1 = "somewhat or sometimes true", 2 = "very true or often true"). The behaviour is divided into eight problem areas/syndrome scales called Withdrawn, Somatic complaints, Anxious/Depressed, Social problems, Thought problems, Attention problems, Delinquent behaviour, and Aggressive behaviour. The first three subscales are used to form a composite measure of internalized behaviour, and the last two subscales are used as composite measure of externalized behaviour.

The TRF was applied in Study I and II.

2.2.4. The Illinois Test of Psycholinguistic Abilities (ITPA)

The Norwegian version of Illinois Test of Psycholinguistic Abilities (ITPA) (Gjessing et al., 1975) was administered to assess linguistic abilities. The test is standardised for Norwegian children between 4 and 10 years of age. It consists of twelve subtests assessing various aspects of the language such as receptive processes, associative processes, expressive processes, grammatical abilities and memory span. The material consists of pictures, orally presented questions or sentences, and objects to be handled. The total score on ITPA is based on the first ten subtests.

The ITPA was applied in Study I.

2.2.5. Teacher observation of chosen target skills

Field observation (Patton, 2001) of chosen target skills was undertaken in study II in order to investigate how many children who obtained an M-ABC score at or below the 15 centile also fulfilled the additional DSM- IV criterion, stating that the motor impairment must interfere significantly with activities of daily living in order for the child to receive the diagnosis Developmental Coordination Disorder. The teachers observed the children during performance of the following chosen target skills over a period of two weeks: Running, jumping, climbing, riding a bike, drawing, dressing and outdoor play. The teachers also obtained additional parental information regarding motor function through informal interviews. The teachers' observations and notes were then discussed with experienced paediatric physiotherapists who also had observed the children on several occasions, and they decided on whether the children performed the skills as would be expected according to age, or showed borderline or definite difficulties during performance.

2.2.6. Structured parental interviews

Structured, open-ended interviews (Brewerton & Millward, 2001; Patton, 2001) were applied in study V in order to obtain parental descriptions of the children's motor performance and overall situation in mid-childhood, after intervention at the age of six. The parents of the children in both groups were interviewed based on a structured thematic interview guide, but with opportunities to ask individual follow-up questions. The questions were open-ended, with sub-questions according to the main themes.

The main themes were:

- Description of their children's situation today with regard to coping and social functioning at home and at school
- The children's motivation for and enjoyment of physical activity
- The children's choice and mastery of motor skills, and participation in organized spare time activities
- Retrospective evaluations of the children's motor intervention at the age of six

2.2.7. Participatory action research

A Participatory Action Research (PAR) approach was applied in the projects in study IV. Participatory action research is recommended in order to obtain relevant information from community based health promotion and intervention programmes that cannot be studied within

traditional experimental designs (Hart & Bond, 1995; Minkler & Wallerstein, 2003; Stringer & Genat, 2004; White, Suchowierska & Campbell, 2004). This type of research is context specific, and the process of inquiry is of great importance (Reason & Bradbury, 2001). As described by several action researchers, good action research is a developmental process that emerges over time, alternating between action and reflection (e.g. Brydon-Miller, Greenwood & Maguire, 2003; Coghlan & Brannick, 2001; Stringer, 1999). As a consequence, the nature of knowledge obtained during this process is dynamic and evolving (Reason & Bradbury 2001).

Accordingly, our projects were designed to ensure continuous cycles of action and reflection at different levels throughout the project-period. With regard to design, the following main elements developed and were evaluated:

- Participatory multidisciplinary introductory day in the Spring semester before school start
- Participatory multidisciplinary activity week in the Autumn semester after school start
- Follow-up activities agreed upon in the various local multidisciplinary school-teams
- Supportive multidisciplinary and professional specific lectures, seminars and work shops
- Annual multidisciplinary dialogue conferences

Important cycles of action and reflection that took place are described in more detail in the following:

The work carried out by each local school-team each school year was organised as a continuous cycle of action and reflection: 1) The team planned the participatory multidisciplinary week of action, 2) Practical team actions took place during the actual week, 3) The team reflected and evaluated the week, 4) The team decided on and carried out follow-up activities, 5) The team evaluated the follow-up activities, 6) New team planning of actions for the next school year.

Similar cycles of action and reflection were also organised each year within each attending external group of professionals: 1) Each attending professional group planned how to use the available resources during the particular school-year, 2) The group reflected on specific professional contributions during the participatory week, 3) Chosen activities were carried out during the participatory weeks, followed by group reflections afterwards on what worked well/what did not.

The annual dialogue conferences provided an opportunity for people from the different local teams and municipalities to meet and reflect on the project face-to-face. Last years activities were presented by the local teams and discussed, and new actions were suggested and implemented the following year.

2.2.8. Participatory observation and participatory evaluative techniques

The main evaluative tool of the participating professionals was participatory observation (Adler & Adler, 1994; Patton, 2001) during the participatory multidisciplinary activity week, and for some also during the participatory introductory day. Based on participatory observation each local team evaluated each participatory week, and evaluations were summarized in written reports. In order to ensure a shared focus at the attending schools, the participants developed an observational guide during the first project-year. The guide covered the following main areas: Observation of in- and outdoor areas and school facilities, observation of class structure and organization, observation of group interaction, observation of teacher-child interaction, and observation of social and motor function of individual children. As active participation in natural situations was the working method, the guide was not actually brought on site, as we considered that this would disturb the natural flow of activities and interaction. The guide was used preparatory and during discussions at supportive workshops. As described by Adler and Adler (1994), the degree of participation during observations is variable, depending on the focus and specific aims of the study. In the projects in study IV, all professionals described and evaluated the activities that took place based on active participatory observation.

In order to include participants actively in the on-going processes, visual evaluation techniques such as drawings, matrixes and various types of mapping diagrams from the Participatory Learning and Action (PLA) framework, as outlined by Chambers (1997, 2002) and Pretty, Guijt, Thomson & Scoones (1995), were used during planning and evaluation on all levels throughout the projects. We also made use of participatory dialogue conferences (Gustafsen, 2001) as an evaluative tool. During these conferences visual techniques were used extensively.

2.2.9. Qualitative analyses

In study IV we organized the analytic processes in the administrative project teams as flowing circles of action and reflection. As these teams were responsible for summarizing local and regional evaluations, writing preliminary reports and implementing suggested changes of actions on a regional level, the evaluative circles will be specifically described: We (the project administrative teams) asked the local teams to evaluate each participatory week according to “what went well” and “what can be improved”, and recommended the use of a simple Sun/Cloud diagram as evaluative technique. We collected and summarized the local material, and as a further evaluative step, we categorized data in the main categories “outcomes” and “processes”, with suitable subcategories. Finally, we added data from the dialogue conferences and professional group evaluations, and made annual summarizing reports. Preliminary reports and

project material were sent by e-mail to the local participants, and also made available on websites (Iversen, 2003). We encouraged all participants to comment on available preliminary evaluation material and reports.

As yet a further evaluative step, evaluative material from both regions was compared and analyzed. In order to get outside input during this process, data were discussed with two reflective teams; one internal which consisted of a teacher and a physiotherapist with extensive field-practice, but with no involvement as administrative team members, and one external which consisted of three professionals with no involvement in the project at all, but with extensive knowledge of children with developmental difficulties as well as competence with regard to general health issues. Analytic techniques such as drawings, time-lines and matrixes after models from Pretty et al. (1995) and the tree-diagram as outlined by Wolcott (2001, pp. 90) were applied. During the analyses we focused on capturing the developmental processes of major issues such as competence building, project organization, services to vulnerable children and implementation of health promoting programmes and activities.

In study V, written transcripts of the interviews of the parents were summarized and categorized according to the main themes of the study, addressing motor and social function at the ICF levels of activity and participation.

2.2.10. Statistical analyses

Data from the studies yielding empirical data were analyzed with regard to skewness and normal distribution (Paper I – III and V). Parametric or non-parametric analyses of differences and relationships were carried out as appropriate using the SPSS version 10 (Paper III), 11 (Paper I and V) and 13 (Paper II). In addition Cohen's d power analyses were carried out as appropriate. In Paper III sensitivity and selectivity of the data with regard to correctly classifying poor readers and controls were analyzed using discriminant function analyses.

For further details, see the separate articles.

2.2.11. Overview of evaluative methods

Figure 2 summarizes and presents an overview of the evaluative methods of the five separate studies included in the thesis.

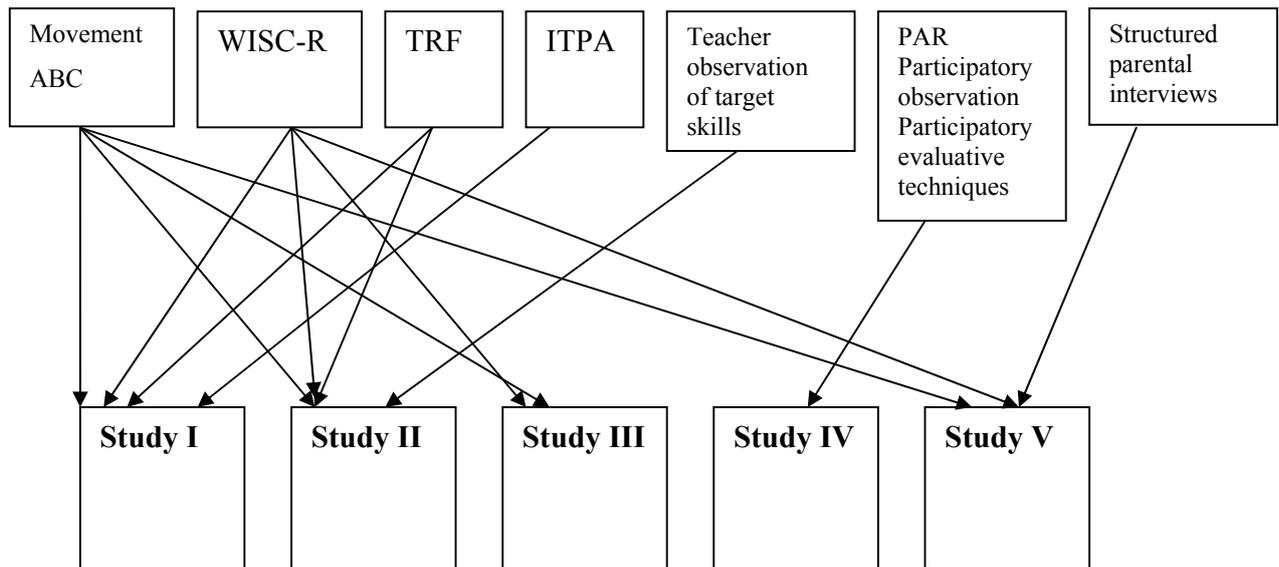


Figure 2: An overview of the evaluative methods of the separate studies

3. RESULTS

In this section, a synopsis of the findings from the five papers will be presented.

The M-ABC (Henderson & Sugden, 1992) was used in four of the five studies, and as already described; specific standardization of the test has not yet been carried out in Norway, even though some evaluative work has been undertaken. In order to validate our findings for 5-6-year-old children in study I, II and V, a sample of 146 first grade children were assessed with the M-ABC. These data have not yet been published, but an overview is presented.

3.1 Paper I

Behavioural and emotional problems hamper learning and normal development of skills and abilities. The children in focus in this study were 6- year-olds with persistent behavioural and emotional problems. The aim of the study was to assess the participants' behaviour as well as cognitive, linguistic and motor skills and correlate behaviour and skills. Thirty-one children enrolled in a high-risk programme participated. Standardized methods were used to obtain information on behaviour and skills: TRF, WISC-R, ITPA and M-ABC.

The most severe problems were registered in social interaction and attention. Scores lower than normative mean were detected on WISC-R, ITPA, and severe motor problems were observed in more than half the group. Significant correlations were found between behavioural traits, between attention problems and cognitive skills, and between motor skills and problem behaviour.

3.2. Paper II

In this study incidence, severity and types of motor difficulties in children with persistent behavioural and emotional problems were evaluated. A high-risk group of 6-year-olds (n=29) with severe behavioural and emotional problems and an age and gender matched control group (n=29) were assessed using the M-ABC. The two groups were compared regarding total motor impairment scores as well as motor function within the areas of manual dexterity, ball-skills and balance. Motor profiles on the M-ABC for children with specific types of behavioural and emotional problems as assessed with TRF were also investigated.

It was found that 62.1 % in the high-risk group and 20.7 % in the control group showed borderline or definite motor coordination difficulties at or below the 15th centile. In the clinical group 55.2 % fulfilled the criteria of the DSM-IV for developmental coordination disorder, compared to 3.4 % of the controls. The high-risk group showed a mixed profile, with significant difficulties within all sub-areas of the M-ABC compared to controls. Investigation of motor profiles for children in the high-risk group with specific types of behavioural and emotional problems showed a significant relationship between attention problems and manual dexterity difficulties, and continuous, precise movements stood out as particularly difficult. The combination of severe behavioural and emotional problems and DCD makes the children in question vulnerable with regard to inclusion, which in turn has implications with regard to choice of assessment and intervention strategies.

3.3. Paper III

The purpose of the study was to investigate incidence, severity and types of motor problems in two groups of poor readers compared to good reading controls. A group of children with severe dyslexia referred for specialist evaluation, a teacher selected municipality sample comprising the 5 % poorest readers, and a control group consisting of the 5 % best readers were all assessed using The M-ABC. The three groups were compared with regard to total motor impairment scores as well as motor function within the areas of manual dexterity, ball-skills and balance.

More than 50 % of the children in both groups of poor readers showed definite motor coordination difficulties at or below the 5th centile, compared to 13.6 % of the good reading controls. Children in both groups showed difficulties within the sub-area of manual dexterity in particular and also performed significantly worse than controls within the sub-area of balance, but not in ball-skills. Continuous precise fine motor movements stood out as particularly difficult. The high incidence of motor coordination problems in the two groups of poor readers indicates that all children with reading difficulties should be screened for possible motor difficulties.

3.4. Paper IV

The article presents how participatory action research was applied during two 3-year projects at 27 schools in Norway in order to enhance the quality of school start. The projects comprised first

grade children and their teachers, as well as professionals from the municipal health- and educational services.

The projects were reported to improve multidisciplinary team-work and professional relations, increase focus on developmental and health care issues, develop professional knowledge and practical skills, increase support to local educational staff, and provide a better school start for children with developmental problems and disorders and other vulnerabilities. Local creativity and ownership within supportive administrative structures were reported as promoting factors, while available time and available external professional resources stood out as main constraints. The construction of learning partnerships based on face-to-face interaction appeared to be a particular strength of the approach.

3.5. Paper V

The aim of the study was to evaluate motor function in mid-childhood for two groups of children with motor coordination difficulties, who had received intervention at the age of 6. For group A a high-dosage, targeted motor skills approach with a high degree of parental involvement had been applied, while group B had received a low dosage, basic motor skills approach with limited parental involvement. Parental follow-up descriptions of the children's situation at home and at school 1-4 years after intervention, with primary focus on motor function at the levels of activity and participation, were compared with motor function as assessed with the M-ABC.

No significant differences were found with regard to M-ABC sum-scores, but the parents from group A reported an overall more favourable situation at the levels of activity and participation. The children in group A were physically active, with frequent use of targeted motor skills learned during intervention. The majority of children from both groups displayed comorbid learning difficulties and attention deficits at follow-up. Parents considered their children vulnerable and worried about future social functioning.

For group A pre-and post training M-ABC scores were available, and were compared with the M-ABC follow-up score. The significant progress registered from pre- to post-training remained stable 1-4 years after intervention.

3.6. Evaluating the motor competence of first grade Norwegian children on the M-ABC

A total of 146 children (72 boys, 74 girls) representing three different year-groups participated. Written informed parental consent was given. Their birthdays were evenly distributed throughout the year, with a mean age of 6.42 years. One year-group belonged to a typically all-inclusive Norwegian school in a city on the West coast, while the remaining groups represented typically all-inclusive schools in a middle-sized municipality in the Eastern part of Norway. All children were assessed at their local school by experienced paediatric physiotherapists. Six different testers participated. Preparatory video-analyses and discussions of testing- and scoring procedures were undertaken.

The mean total impairment score was 4.4 (SD=4.0), compared to 5.1 (SD=4.5) for 6-year-olds in the American standardization sample (Henderson & Sugden, 1992, p. 202). Severity of motor problems in the total sample is summarized in Table 1. As shown in the table, 6 children (4.1 %) obtained a total impairment score at or below the 5th centile, which corresponds to the clinical level, while 11 children (7.5 %) obtained scores within the borderline area. A total of 129 children (88.4%) obtained scores within the normal area.

Table 1: Number and percentage of children (n=146), who obtained total M-ABC scores at a clinical level (≤ 5 centile), borderline level (> 5 to ≤ 15 centile) or at a normal level (> 15 centile)

	Number of children	Percentages
Clinical scores	6	4.1 %
Borderline scores	11	7.5 %
Normal scores	129	88.4 %

Scaled M-ABC scores for each test-item were compared between the sexes, and the results are presented in Table 2. Two-tailed *t*-test was applied, with no significant differences registered.

Table 2: Mean values and standard deviations (SD) on M-ABC items for 6-year-old Norwegian children (72 boys, 74 girls)

M-ABC items	Boys (n=72)		Girls (n=74)	
	Mean	SD	Mean	SD
ManDex 1	0.43	0.72	0.27	0.64
ManDex 2	0.40	0.89	0.61	1.13
ManDex 3	0.54	1.02	0.7	1.17
Ball 1	0.41	1.07	0.50	0.91
Ball 2	1.26	1.36	1.36	1.49
Balance 1	0.34	0.70	0.37	0.91
Balance 2	0.88	1.62	0.68	1.37
Balance 3	0.03	0.16	0.11	0.45

As can be seen from the table, the most demanding item for the Norwegian sample was Ball 2, while Balance 3 received the lowest mean value.

4. DISCUSSION

This chapter is outlined as described in the following: First, the results from the studies are discussed, emphasizing their contribution to the knowledge about the complexity of developmental problems and disorders, as well as to the registration of different types of motor problems and their clinical consequences. Based on the results, different approaches to assessment and intervention for children with motor coordination difficulties and associated problems are also discussed. Second, methodological considerations are presented.

4.1. The complexity of developmental problems and disorders

The results from study I, II, III and V of this thesis emphasize the complexity and vulnerability of children with developmental problems and disorders, and highlight a high rate of comorbid difficulties. Study IV was especially designed to improve school start for this complex group of children as well as for first grade children in general. The broad evaluation of the high-risk children in study I showed a high degree of overlap between behavioural and emotional difficulties, attention deficits, language problems and motor coordination difficulties. Assessment of possible motor coordination difficulties in children with behavioural and emotional difficulties (study II) and reading problems (study III) showed a high incidence of severe motor coordination difficulties compared to normal controls. The parents of the children with DCD in study V reported attention deficits and learning problems as commonly co-existing problems. The attending professionals in study IV reported multi-modal difficulties concerning children with developmental problems and disorders, and pointed to the participatory multidisciplinary approach as valuable in order to deal with this clinical complexity. All these findings are in line with earlier research showing co-occurrence of developmental difficulties as a rule rather than an exception (e.g. Dewey et al., 2002; Gillberg et al., 2004; Kadesjö & Gillberg, 1998; Kaplan et al., 1998; Ramus et al., 2003). However, seemingly pure cases of motor coordination difficulties were also reported (study III and V), and quite a few children in study I, II and III did not display motor problems at all. This variability emphasizes the individuality of the children's difficulties, with consequences for choice of terminology, assessment- and intervention strategies. As discussed by Wilson (2005), until recently formal assessment for DCD was neglected in the health care systems in the West. Motor coordination difficulties were as a consequence often detected at a late point, if acknowledged at all, which still seems to happen to a certain degree, as

indicated in study I, II and III. Children with behavioural and emotional difficulties (study II) are traditionally assessed within medical/psychiatric settings, while children with reading problems (study III) traditionally are assessed within educational settings. The results from the broad evaluation of high-risk 6-year-old children undertaken in study I, demonstrate that even though one type of developmental problems often stand out, it is important not to neglect other developmental areas during assessment of young vulnerable children.

In line with earlier research (Cantell et al. 1994, 2003; Christiansen, 2000; Losse et al. 1991) the findings in study III and V, which comprised children in mid-childhood, indicate that many children do not “grow out” of their motor coordination difficulties. Earlier research has shown persisting difficulties for those with severe motor coordination difficulties in adolescence and even as grown-ups (Cantell et al., 2003; Cousins and Smyth, 2003; Rasmussen and Gillberg, 2000). A particularly gloomy prognosis has been reported for young grown-ups if severe motor coordination difficulties are combined with attention deficits and learning problems (Rasmussen & Gillberg, 2000). In study V, both groups displayed a high rate of learning- and social problems, as well as parent- and teacher reported attention deficits and behavioural problems, thus resembling description of children with DAMP by Gillberg et al. (1983) or Dewey et al.’s (2002) description of children with ABD. The results from study V indicate that although early, high-intensity task specific motor intervention cannot resolve motor problems shown in 6-year-old children with DCD, regular practice and mastering of culturally valued motor skills can improve physical fitness and promote inclusion and social function, even for those with severe combinations of motor difficulties, attention deficits and learning problems. These are promising results that need to be further documented.

Research by Cantell et al. (2003) and Hadders-Algra (2002) have pointed out two different pathways for children with DCD and associated conditions, or using the term of Hadders-Algra (2002), for children with MND. While those severely affected do not grow out of their problems, children who at a young age exhibit medium/minor problems, seem to have a far better prognosis, with clear improvement for many. Pless, Carlsson, Sundelin and Persson (2002) evaluated 7-8 year-old children with DCD who had received intervention at the age of 6, and reported a similar pattern. In study V we found children in both groups who scored within the normal range at the M-ABC and who did not display any problems with regard to motor function at activity level, indicating that the motor problems registered at the age of 6 had been resolved.

4.2. Types of motor coordination problems registered

The high-risk children with motor coordination difficulties in study I displayed problems within all sub- areas of the M-ABC, indicating fine- as well as gross motor difficulties. In study II the relationship between severe behavioural and emotional problems and motor coordination difficulties were investigated at multi-level and in more depth. A high incidence of severe motor coordination difficulties were registered, with more than half of the group fulfilling the DSM-IV criteria for DCD, compared to less than 5 % of the controls. Earlier studies have shown significant overlap between various types of behavioural and emotional problems and motor coordination difficulties in school children (Gillberg et al., 2004), and the results from study II indicate that such a relationship can be detected also in younger children. At activity and participation level, the teachers rated all children with the combination of behavioural difficulties and borderline/clinical scores on the M-ABC as displaying problems during performance of target skills. This was not the case in the control group. In other words, the behavioural and emotional difficulties of the children in the high-risk group seemed to enhance motor coordination difficulties at activity and participation level negatively. The combination of severe behavioural and emotional problems and DCD makes the children in question particularly vulnerable with respect to social function and participation in culturally valued motor skills.

While studies concerning co-occurrence of attention deficits and motor coordination difficulties in school children are starting to accumulate (e.g. Christiansen, 2000; Piek et al., 1999; Pitcher et al., 2002), there is limited research concerning younger children. However, the significant relationship between clinical attention scores and manual dexterity problems in 6-year-old children reported in study II is supported by earlier research from Kalff et al. (2003). As in the Kalff et al. (2003) study, the children with attention deficits in study II showed less accuracy and more variability in their movements compared to controls. Test-item 3, resembling writing, stood out as particularly difficult. Performance of this task requires precise, continuous movements, which put great demand on sustained attention and high-level controlled processing. This type of manual dexterity problems are also in line with the findings of Kalff et al. (2003), who reported these kinds of difficulties in 5-6 year old children later diagnosed as ADHD. Kalff et al. (2003) explained their findings as indicative of a specific deficit in high-level controlled processing, in addition to generally poor motor control, which also involve low-level processing.

Etiology of behavioural and emotional difficulties is complex, and our results point to early motor evaluation as helpful in order to clarify the picture with regard to the nature of the behavioural difficulties. Interestingly, there is evidence that early systematic observations of

motor function in high-risk infants may provide important clues to future problems and diagnoses. As shown by Fallang et al. (2005) in their longitudinal study of pre-term infants, the presence of non-optimal quality of reaching at 6 months was associated with the development of complex MND at school age. Hadders-Algra and Groothuis (1999) reported that definitely abnormal general movements (GMs) between 2 and 4 months were associated with a high risk of developing cerebral palsy, while mildly abnormal GMs were associated with the development of minor neurological dysfunction, ADHD and behavioural difficulties. More research is needed in order to clarify early clinical movement parameters and establish clinical observation procedures.

Study III demonstrated a strong degree of co-occurrence between reading problems and motor coordination difficulties, with an incidence of 53 % and 60 % of severe difficulties in the two groups of poor readers. Our findings are in line with previous research applying the same type of general, norm-based measurement (Dewey et al. 2002; Kaplan et al., 1998; Sugden & Wann, 1987). It may be somewhat surprising that the groups differed little with respect to degree of problems, but this indicates that it is important to consider possible motor coordination difficulties in all children with reading problems, not only severe dyslectic cases (Dewey et al., 2002; O'Hare & Kalid, 2002). With regard to types of motor difficulties, both groups of poor readers had significant difficulties performing the manual dexterity and balance tasks, but not the ball-skills task, compared to controls. Jongmans, Smits-Englesman and Schoemaker (2003) reported a similar pattern for children with DCD and learning difficulties (LD). Fawcett and Nicolson (1992, 1999) and Nicolson and Fawcett (1990, 1994, 1999) have reported high prevalence of motor difficulties in the sub-area of balance when an interfering cognitive task was introduced. Applying the same tasks and types of assessment, other researchers have reported that the balance problems seemed confined to children with dyslexia and comorbid ADHD (Raberger & Wimmer, 2003; Wimmer et al., 1999). In study III, none of the children had an additional ADHD diagnosis. However, they were not screened for ADHD related symptoms, leaving open the possibility that children with these kinds of symptoms might show an increased rate of motor difficulties compared to poor readers without such symptoms. Future studies should systematically screen for attention related difficulties.

The fact that manual dexterity stood out as the most difficult area for both groups of poor readers adds support to the importance of clarifying the relationship between attention deficits, reading problems and motor coordination difficulties. Comparable to the findings of a significant relationship between attention deficits and difficulties with continuous fine motor movements in Study II, the test-item Manual Dexterity 3 stood out as particularly demanding for both groups of

poor readers. As already described, this task resembles the task of writing, and the results indicate that many children with reading problems may experience serious difficulties with the motor aspects needed in writing, with clinical implications.

While the children with reading problems were not assessed for possible motor difficulties at the levels of activity and participation (WHO, 2001), the children with DCD and associated difficulties in study V were evaluated by their parents at these functional levels. The M-ABC assessment showed profiles of fine- as well as gross motor difficulties for the majority of the children from both groups involved in the study, regardless of type of intervention received at the age of 6 years. Parental evaluation of culturally important motor skills showed a different picture, favouring the children who had received the high-intensity, task specific intervention. Interestingly, and in need of further studies, the significant motor function improvement registered during the high-intensity task specific programme remained stable for 1- 4 years as measured by the M-ABC as well as evaluated through observations of target skills. Practiced skills such as bicycling, swimming and skiing were still important activities, and the children in the high-intensity task specific group presented themselves as physically active. As such, depending on type of intervention received at the age of 6 years, registration of motor difficulties at activity and participation level revealed a diversified picture, with promising aspects concerning high-intensity, task specific intervention.

4.3. Other types of motor vulnerabilities registered

Study IV highlighted that while children with developmental deficits were of great concern to the teachers at school start, other vulnerabilities also needed to be addressed, such as physical inactivity and obesity. Increased teacher competence and promotion of physical activity were reported as important results in the participatory action projects in both regions. On an individual level, teachers and physical therapists claimed that many inactive and inexperienced children improved their motor function with the help of extra focus and promotion of physical activity from the teacher. Importantly, children with developmental problems and deficits are reported as particularly vulnerable with regard to life style induced difficulties, and could easily become trapped in negative activity circles, with severe long-term health implications (Bouffard, Watkinson, Thompson, Dunn & Romanov, 1997; Harvey & Reid, 2003; Missiuna et al., 2003). Providing a multidisciplinary focus at school start, with active on-site participation from the

supportive municipal health- and education system, enhances a broad, contextual focus during an important and vulnerable period in the lives of the children.

4.4. Approaches to assessment

Based on the results of the studies presented, the children with developmental problems and disorders stood out as a complex, variable and vulnerable group. As mentioned, while the majority of children evaluated presented with concomitant difficulties, pure cases of developmental disorders were also identified. As highlighted by Henderson and Henderson (2000) and Ramus (2003), the occurrence of pure cases within the developmental disorders raises important questions: What characterizes these children with respect to developmental qualities? How do they compare to children with comorbid difficulties? In order to obtain answers, researchers from various fields working with developmental disorders need to study and compare pure, as well as comorbid cases carefully in target areas such as attention, motor functioning, auditory and visual information processing, general cognitive functioning and specific learning abilities. In order to make such comparisons possible, a consensus is needed with regard to basic measurements within the various target areas. In addition, specific measures matching the research questions of each particular study should be added.

The results of the papers discussed point to the importance of broad, functional multi-level evaluations. In line with Rogder et al. (2003) we recommend that assessment should be undertaken at all the functional levels of the ICF (WHO, 2001). The need for this was demonstrated in study II: While several children in the control group with borderline and clinical scores on the M-ABC did not exhibit motor problems at activity and participation level, all children with behavioural and emotional difficulties did. The results from study V provides another example; while both groups of children with DCD still displayed motor difficulties as measured by the M-ABC 1 – 4 years after intervention, evaluation at activity and participation level showed differences between the groups depending on which type of intervention that had been applied. If evaluation had not been carried out at activity and participation level, this important group difference would not have been detected. A third example from the reported research is the lack of data from activity and participation level in study III, which limits conclusions about possible everyday life effects resulting from the motor problems registered in children with reading problems.

As highlighted by Geuze et al. (2001) in their extensive review of studies concerning children with DCD, the majority of the studies did not evaluate children at the levels of activity

and participation, but applied borderline or clinical scores from norm-based, standardized tests such as the M-ABC and the BOTPM as a basic diagnostic measure of DCD. As pointed out by Henderson and Barnett (1998), the lack of guidelines concerning evaluation of criterion B of the DSM-IV diagnosis of DCD is a problem. Although teacher and parental questionnaires have been developed, such as the C-MABC (Henderson and Sugden, 1992) and the DCD-Q (Wilson et al., 1998), problems regarding reliability and validity are reported (Green et al., 2005; Junaid et al. 2000; Piek and Edwards, 1997). In their recent evaluative study of C-MABC and DCD-Q, Green et al. (2005) concluded that although parental reports were of some value, a full clinical assessment must be undertaken in order to obtain a full picture of a child's motor coordination difficulties. In study IV multidisciplinary participatory observation was applied in order to evaluate children with developmental problems and deficits at the levels of activity and participation, including motor coordination difficulties. Active on-site observation over time proved a valuable tool in order to detect and evaluate developmental problems, and importantly, also to detect strengths and establish individual activity profiles. The multidisciplinary team observation was reported as particularly valuable for children with comorbid difficulties. The on-site observations did not exclude specific clinical assessment, but were undertaken as a first step with formal referral as a follow-up procedure if necessary.

4.5. Approaches to intervention

Intervention can be seen as being directed towards improvement at the levels of body structure and function, activity and participation within the framework of the ICF (WHO 2001). As already described, the difficulties of children with developmental problems and deficits are frequently multi-modal and manifested at all ICF levels (Cermak et al., 2002; Rodger et al., 2003; Wilson, 2005), a picture that was confirmed in the papers discussed. This calls for a subsequent need to design intervention programmes and evaluate effects based on a broad, dynamic and multidisciplinary perspective. Within such a basic framework chosen target areas should be addressed, depending on individual developmental profiles, the child's age and activity profile, and additional factors such as the family's experience of the problems and local intervention possibilities.

Study IV and V addressed the question of organization and effects of intervention. Study IV focused on building supportive multidisciplinary intervention structures for all children with developmental problems and disorders at school start. Study V addressed the choice and effect of

motor intervention strategies for 6 year-old children with DCD and associated conditions. As already described, the children participating in the high-intensity, task specific programme (hereafter termed group A) showed significant improvement from pre- to post-training as assessed with the M-ABC, and the improvement was stable at follow-up. The activities learned at the age of 6 were still important for the children, with reported positive social implications, and they were coping well in gymnastics and outdoor play. A large majority participated in organized spare time activities and maintained a high level of physical activity. While the M-ABC assessment at follow-up did not reveal significant differences between the two groups in study V, a less positive outcome was reported for the children who received a low-dosage, basic motor skills approach (hereafter group B) at the levels of activity and participation.

A considerable amount of resources were invested at an early age for the children in group A. The time of onset was comparable for the children in programme B, but with markedly lower intensity of training. In order for motor learning to occur, a certain number of repetitions are required (Larin, 2000). Earlier research has emphasized the importance of intensity of training, and training periods consisting of 3-5 weekly sessions have been recommended for children with DCD (Pless & Carlsson, 2000; Sigmundsson et al., 1998). In study V both groups received motor training during a crucial developmental time span for the refinement of basic motor skills such as running, climbing, jumping, catching and throwing (Campbell, 2000). At a structural level, intervention took place within the developmental time-span of extensive synaptic rearrangement (Johnston, 2003; Hadders-Algra, 2002). The term “adaptive plasticity” refers to adaptive organization of brain circuits in response to sensory stimulation (Johnston, 2003). Cortical synaptic density is high during early development, and plastic reorganization occurs through a process of activity-dependent refinement and pruning of synaptic connections (Bailey, 2002; Johnston, 2003; Lebeer, 1998). With respect to the intervention approaches applied in study V, the time of on-set, duration, intensity and motor skill specificity of programme A may have affected activity-dependent synaptic stabilization and sculpting resulting in long-term changes in structure and number of synapses. The stable results at follow up of improved post-training motor performance for group A lend support to this possibility.

Missiuna et al. (2003), recommended activities such as swimming, skiing and bicycling, which contain sequences of repetitive movements for children with DCD, and argued that once learned, children with DCD can indeed become successful. In contrast, activities such as ballgames contain a high degree of unpredictability, which in turn require constant monitoring and adaptations in response to environmental feedback. The findings of study V give support to

Missiuna et al.'s (2003) recommendations, as motor skills containing repetitive elements were mastered and actively used by almost all children in group A, while ballgames were still reported as difficult for a large number. However, the fact that some children in both groups did participate and enjoyed ballgames warrants an additional comment. These findings are in line with the results of Smyth and Anderson (2001) reporting that 10 out of 32 boys in a movement-impaired group did indeed play football for a considerable amount of time. This points to considerable variability with respect to inclusion and participation in socially valued team-games within groups of children with DCD, and highlights the importance of establishing individual profiles at the functional levels of activity and participation.

The chosen activities in programmes A and B required different motor learning environments. While the basic motor skills approach in programme B took place in a gym, the learning of cycling, swimming, and skiing took part in other types of environments. In programme A ball skills and basic motor skills were practiced in- and outdoors, making the learning of these types of activities more comparable to real-life situations. In a dynamic system perspective, motor learning is viewed as the result of interaction between cognitive, perceptual, mechanical and neurological internal mechanisms, as well as interaction of the individual with the task and the environment (Carr and Shepard, 1998; Magill, 2001; Shumway-Cook & Woollacott, 1995). Variable practice of externally focused goal-directed motor skills is reported to enhance motor learning (Carr & Shepard, 1998; Wulf et al., 2003, Wulf et al., 2004). In programme A the children actively explored the activities under variable conditions, thus promoting understanding as well as automatization and generalization of the various skills (Carr and Shepard, 1998; Magill, 2001). In contrast, the children in programme B were not given the same opportunities for variable exploration.

Play, game and sport activities vary by age, gender, cultural traditions and local opportunities with implication for assessment and intervention for children with DCD (Watkinson, Dunn & Cavaliere, 2001). Thus, the choice of target skills becomes important when motor intervention is planned. The parents in group B pointed to the social limitations caused by the lack of skills such as bicycling, running fast, skipping, skiing, skating and ball-skills. In contrast, the parents in group A mentioned only ball-skills. A possible explanation could be that the children from group A had established a repertoire of "resource" activities, which gave themselves and their parents a sense of confidence and mastery. However, the children from both groups still presented themselves as socially vulnerable 1- 4 years later, and the parents from both groups worried about the future. Similar findings have been reported from earlier research (Cohn,

2001; Pless, Persson, Sundelin & Carlsson 2001). Schoemaker, Hijlkema and Kalverboer (1994) suggested early motor intervention as a possible tool in order to prevent social and affective difficulties for children with DCD. The results in study V indicate that even though children with DCD and associated conditions have learned culturally important motor skills at an early age, they are still vulnerable with respect to peer-interaction and participation.

4.6. Building multidisciplinary structures and increasing competence

Based on the previous discussion, a basic multidisciplinary perspective stands out as essential in order to understand the vulnerabilities and difficulties of children with developmental problems and disorders, as well as applying adequate evaluation and intervention strategies. Health- and educational systems vary between different countries and cultures. In Norway all-inclusive schools are established as a norm, with inclusion advocated as the educational ideology (UNESCO, 1994, 2003). Norwegian municipalities also provide supportive municipal health- and educational services from physio- and occupational therapists, school nurses and physicians, special educators and psychologists. Traditionally, these external professionals have focused on providing services to children with various types of needs referred to the supportive consultative system. With the exception of services from school nurses and physicians, general health and developmental issues have so far received limited attention. Although the various groups of professionals have cooperated, this has mainly taken place through formal meetings and the exchange of paperwork, with collaboration restricted to individual cases. During the participatory action projects presented in article IV, a new and different way of working together was developed and evaluated. The broad multidisciplinary focus stood out as clinically relevant in order to take care of all types and groups of children, with the on-site, face-to-face interaction between children and different groups of professionals as a particular strength of the approach. Important formal as well as informal multidisciplinary structures were built, and increased competence, increased implementation of developmental and health care programmes and a better school start for vulnerable children was reported. From their research on effective school transition programmes, Dockett and Perry (2001) pointed to the building of relations between all participants as crucial in order to succeed. As exemplified in study IV, the development of methods and arenas that facilitate all participants getting to know each other seems to hold the potential of developing effective partnerships and learning networks (Gustafsen, 2001; Senge & Scharmer, 2001).

Viewing the findings in study IV in a health- and developmental promoting framework, the issues of physical activity, diet and aspects of emotional health were strongly focused, with

reported positive changes in school structures and teacher competence. In order to obtain long term physical and emotional health benefits, early intervention is recommended for all these target areas (Bloomgarden, 2004; Gortmaker et al., 1999; Mishara & Ystgaard, 2000; Missiuna et al., 2003). Based on the findings from the projects, it is reasonable to believe that multidisciplinary on-site intervention at school start holds the potential of promoting health on a general basis, thus reducing risk factors and preventing early onset of life-style induced difficulties. As underscored by many participants in both regions, vulnerable children including children with developmental problems and disorders particularly benefited from the general health-promoting structures, programmes and activities applied.

Reporting from the Australian Starting School Research Project, Dockett and Perry (2001) emphasized children's school start as a community issue and responsibility. The participatory multidisciplinary team approach was evaluated to make it easier to include and build supportive structures for children with all types of problems, disabilities and disorders, from minor transitory difficulties to severe medical and/or cognitive problems. The projects depended on the restructuring of limited resources from the municipal health and educational services, and other professional activities had to be reduced. However, community benefits in terms of an improved school start for children with all types of vulnerabilities, with possible positive long-term effects for the children and families involved, is a strong argument supporting the application of the approach. An additional argument in favour of applying the time and resources needed is the reported diffusion of competence and good practice between local teachers and external professionals. It is also noteworthy that the combination of practical field competence and supportive lectures and workshops proved valuable in order to increase competence considered clinically relevant by the attending professionals. Similar findings have been reported in other community-based action research projects (Koch, Selim & Kralik, 2002; Leff, Costigan & Power, 2004; McIntyre, 2000). As such, one can argue that PAR-anchored, targeted educational programmes, which combine practical and theoretical competence, hold the potential of substantial professional quality improvement within the municipal health- and educational services.

Local ownership within the framework of supportive organizational infrastructures enhanced the likelihood of success. Municipality size mattered; the projects revealed that the needed supportive infrastructure rather quickly became established in some of the municipalities in the North, while establishing new organizational structures in a large municipality such as Stavanger proved more difficult, with organizational variations between the involved city-

districts. Reported structural variations between schools also pointed to the acknowledgement of the approach by the school administration as crucial in order to build sustainable and flexible local infrastructures.

In study IV local ownership and method flexibility, which allowed and stimulated local solutions and creativity, were pointed out as crucial factors for success. These findings are in accordance with reports from other community based participatory action research projects (e.g. Bostock & Freeman, 2003; Ho, 2002; Hughes, 2003; Koch et al, 2002; Leff et al., 2004). However, in study IV maintaining a true participatory approach over time turned out to be a continuous challenge, and the importance of keeping the participatory approach "alive" became highlighted. In order to facilitate sustainable participatory processes, one can argue that the notion of local "re-creation" as opposed to "replication" has to be established as a basic idea. Along this line of thought, the approach must be allowed to change and develop based on continuous participatory reflection and action (Senge & Scharmer, 2001; Simmons & Gregory, 2003).

4.7. Discussion of design and use of measures

The purpose of the thesis was to apply a multidisciplinary approach to children with developmental problems and disorders, focusing on selected clinical aspects. Within this basic framework, motor coordination difficulties were particularly focused. In order to reflect the clinical reality, the thesis focuses on assessment as well as intervention. The wide scope can be seen as increasing the clinical relevance, and as such be considered a strength, but it also contains limitations with regard to possibilities for in-depth research on one particular group or aspect of children with developmental disorders. Investigation of motor coordination difficulties in children with behavioural and emotional difficulties and children with reading problems were specifically chosen, as motor problems so far has been frequently overlooked in both groups, with negative clinical implications (Dewey et al., 2002; Gillberg et al., 2004). Other clinically relevant groups could have been chosen, for example children diagnosed with ADHD.

Assessment and evaluation of motor function is at the heart of the thesis. In line with recommendations based on the extensive review undertaken by Geuze et al. (2001), the M-ABC (Henderson & Sugden, 1992) was chosen as the main evaluative instrument of motor function, and was used in four out of five studies. The M-ABC has been well validated internationally (Geuze et al. 2001; Henderson & Sugden, 1992) and cross-cultural comparisons have also been undertaken in Norway (Mæland, 1992; Sigmundsson & Rostoft, 2003) and Sweden (Rösblad &

Gard, 1998). As shown in the result section, we found a percentage of children who obtained scores in the clinical and borderline area that are in acceptable agreement with the original norms. Thus, the assessment of 146 first grade children suggest that the norms for the M-ABC only need minor adjustments for 5-6 year-olds for use in Norway. As in the original standardization sample, no significant gender differences were registered, indicating that the norms can be applied interchangeably for both sexes also in Norway within this age group. However, further validation needs to be undertaken. While our findings are in line with Mæland (1992), who concluded that the norms at the TOMI were acceptable for Norwegian 9-10-year-old children, as well as Rösblad and Gard's (1998) conclusions regarding Swedish children at the age of 6, Sigmundsson and Rostoft (2001) reported significant gender differences for some test-items in a sample of Norwegian 4-year-olds. In our sample, Ball 2 stood out as the most difficult item. Reports from the testers indicated that many children had little experience handling a tennis ball, and that the children improved their performance along with the number of attempts. The low mean value on Balance 3 also calls for an additional comment. Interestingly, Sigmundsson and Rostoft (2001) reported a comparable low mean value on this item in their Norwegian 4-year-old sample, and in study III, comprising a control group of good 10-11 year-old- readers, this particular item received the lowest mean value. One can only speculate why this is so. Are Norwegian children more culturally exposed to balance-challenges, such as walking on uneven surfaces? Further research is necessary in order to examine if this really is a true cultural difference, with implications for M-ABC norms on this particular item.

It is a challenge to identify clinically relevant differences based on standardized scores. Henderson & Sugden (1992) recommended the use of the 5th centile as clinical cut-off point and the 15th centile as borderline cut-off, and we have followed these guidelines. It is important to be aware of the fact that the M-ABC is constructed in order to detect severe motor difficulties, not to differentiate between motor performances within the normal area. In consequence, the scoring range in the borderline area is limited, and covers the range from 10 to 13.5 (10 to 17 for age 4 and 5) points, while the clinical area covers the scoring-range 13.5 to 40 points. As such, reliability becomes a particularly important issue when test-scores within or close to the borderline area are evaluated.

In order to ensure inter-tester reliability in study II, III and V, which involved several testers, preparatory video-analyses, were undertaken. During these discussions a few minor differences in testing-procedures were detected, which could not be answered by the test-manual (Henderson & Sugden, 1992), and these differences were agreed upon. If practically possible, the

testers used the same test-kit and test-rooms in order to further ensure reliability. All testers were experienced paediatric physiotherapists, with extensive clinical practice in applying the M-ABC.

With respect to validity, one aspect concerning the results in study V warrants an extra comment. In study V group A was assessed three times with the M-ABC, pre- and post training and at follow-up. While improvement on all the other sub-tests remained stable from post-training to follow-up, the test-item “static balance” showed a relapse to baseline measures. The task involved in this sub-test is markedly changed when the child enters the 9-10 and 11-12 year age band of the test, from the assessment of static balance on a stable floor surface to assessment on balance boards. Additional analyses not included in the article showed that the children assessed with the 9-10 and 11-12 age-bands at follow-up had a higher impairment score on this specific subtest compared with results from the children assessed with the age-band 7-8 years. This may have resulted in a markedly more challenging task than these children encountered when tested with a younger age-band version of the sub-test, leaving open the possibility that the intervention in question did not affect the demanding and complex type of static balance required by the M-ABC age-bands in question.

In addition to the M-ABC, several other standardized, norm-based measures were applied. The WISC-R, the ITPA and the TRF are all internationally well-validated instruments, and trained and experienced specialists in special education assessed the children. It should be emphasized, though, that testing young children with developmental problems is not easy, and that the results always have to be interpreted with care. The test results may be influenced by the child’s mood, the time of day, or by the tester’s ability to communicate and create a relaxed atmosphere.

In order to obtain descriptions of motor function at the levels of activity and participation, teacher observation of target skills (study II) and structured parental interviews (study V) were applied. Alternatively, measures such as the C-MABC or the DCD-Q could have been applied. In study II resource constraints limited observation of the control group, and only children who obtained total M-ABC scores at or below a borderline level were further evaluated. Alternatively, a parental checklist such as the DCD-Q could have been applied, as this would have been easier to administrate to a large group compared to teacher observation. In study V we did in fact use the C-MABC in order to triangulate parental data with data from the children’s teachers. However, in line with findings from Junaid et al. (2000) and Piek and Edwards (1997), which concluded that teacher identification of children with DCD based on the C-MABC cannot be recommended, we considered the data collected as invalid, due to the fact that many teachers had

difficulties filling out several of the sections in the Checklist. For this reason we decided to rely on data from structured parental interviews only. As a methodologically different type of alternative in study V, in-depth interviews could also have been applied. Such data hold the possibility of providing rich and detailed information regarding personal experiences (Kvale, 1996), and if obtained, data could have complemented and enriched data obtained from structured parental interviews. Information from the children themselves would have been another valuable data-source, and would have enriched all the studies of the thesis, maybe in particular study III and V, which comprised older children.

In study III, the lack of data on motor function at the levels of activity and participation limits the possibilities for clinical interpretation of the results. Further studies should include these evaluative levels in order to clarify clinical implications of the types of motor coordination difficulties registered with the M-ABC.

A multi-modal assessment approach was chosen in study I in order to capture the developmental complexity of young children with persistent behavioural and emotional problems, and to screen for possible co-occurrence of other developmental difficulties. The lack of a normal control group is a limitation to the study, although somewhat compensated for by the fact that only norm-based, internationally validated standardized measures were applied. It could also be argued that triangulation of data concerning behavioural and emotional difficulties could have been obtained if the children's parents had filled out the Child Behaviour Checklist (Achenbach, 1991), because children are reported to behave differently in different settings.

Study II provided an opportunity to specifically investigate motor coordination difficulties in young children with persistent behavioural and emotional problems, and to search for relationships between motor profiles and specific behavioural traits. A suitable randomly drawn, age- and gender matched control group was available. Comparable data on IQ-scores and TRF scores were unavailable from the control group, which is a limitation to the study. However, based on the fact that the control group was randomly drawn from two typically first grade year-groups, normal distribution of data would have been expected.

The participatory action projects in study IV was systematically evaluated at different levels over time, with an active search for outcomes and processes, including factors that promoted or inhibited various aspects of the approach. Due to local variations and gradual school inclusion in the project, a basic qualitative participatory approach to evaluation was chosen, with open-ended evaluative questions answered by the local school-teams as the main evaluative unit as well as repeated discussions during local seminars. In line with PAR principles, participants

were also encouraged to implement changes based on data from the ongoing evaluations at different levels during the project period. In our experience a dynamic participatory research approach like this is especially valuable in order to create local ownership and engaged participants, which are crucial enhancing factors for long-lasting positive outcomes. Application of standardized questionnaires was considered, and such data would have provided a valuable and complementary perspective to the primarily qualitative approach. However, due to the number of schools included, and number of participatory weeks evaluated, the team-reports were summarized, adding a quantifying element to evaluation. As such, viewed in an embedded multiple case perspective (Scholz & Tietje, 2002; Yin, 2003), we consider the main findings as methodologically solid due to the number of separate cases (27 schools) and embedded units (52 participatory weeks). Data from the evaluative reports were also triangulated and confirmed during the dialogue-conferences and discussions within the reflective teams (Yin, 2003).

At the end of the project, the Participatory Multidisciplinary Team Approach was (and is still) considered as standard procedure in the participating regions, and today this work is progressing. This fact points to high pragmatic validity (Kvale, 1989). Bradbury and Reason (2001) highlighted pragmatic questions regarding practical outcomes as a key issue when quality and validity of participatory action research is evaluated. As such, viewed in a PAR perspective, the clinical application of the approach, which is dynamic and still developing, is a major strength of study IV.

Several researchers point to the lack of data concerning long-term effects of different types of intervention as a problem with regard to evaluation of treatment for children with DCD (e.g. Hadders-Algra, 2002; Henderson & Henderson, 2002). Evaluation of the intervention approaches in Study V was clinically derived and undertaken retrospectively. It contains methodological shortcomings with regard to baseline data for group B, due to the fact that pre- and post training M-ABC data were unavailable for the majority of the children in this group. This limits the possibility of comparison between the two programmes. In spite of the unavailability of these data, we did choose to include pre- and post training scores for group A, and compare these with the M-ABC follow-up scores. Programme A contained elements (the on-site targeted motor skills approach, the intensity and length of the programme), which have shown promising results, but so far with only limited research available. Long-term evaluation on the possible effects of this type of programmes is to our knowledge still totally lacking. As such, although in need of careful interpretation due to a limited sample size and lack of control group, the findings of stable M-ABC improvement after intervention and at follow-up, can be considered

a preliminary and promising step in need of further validation. The fact that parental descriptions pointed to the approach undertaken in programme A as effective and valuable at activity and participation level compared to group B, add support to the importance of further validation.

5. CONCLUSIONS AND IMPLICATIONS

The present thesis demonstrates that children with developmental problems and deficits represent a complex, variable and vulnerable group. While the majority of children evaluated presented with concomitant difficulties, pure cases of developmental disorders were also identified. Motor coordination difficulties stood out as a commonly co-existing problem in 6-year-old children with persistent behavioural and emotional difficulties as well as in school children with reading problems. The results of studies I and II strongly support the importance of broad, multidisciplinary evaluation of young children with behavioural and emotional problems considered at risk with regard to inclusion in ordinary schooling. More than half of the high-risk group evaluated displayed clinical motor coordination difficulties as assessed with the M-ABC, presenting fine- as well as gross-motor difficulties. The in-depth investigation (study II) of motor profiles on the M-ABC for children with specific types of behavioural and emotional problems revealed a significant relationship between attention deficits and manual dexterity problems, pointing to continuous, precise fine motor movement as particularly difficult. The results in study III showed an incidence of clinical motor coordination difficulties, as assessed with the M-ABC, of more than 50 % in a group of children with a diagnosis of dyslexia, as well as in a teacher selected sample of poor readers. Compared to controls, significant difficulties were found in the sub-areas of Manual Dexterity and Balance, while the assessment of Ball Skills revealed no significant differences. Continuous precise fine motor movements, which resemble the task of writing, stood out as particularly difficult for both groups of poor readers, indicating that many children with reading problems also display severe difficulties with the motor aspects of writing.

Further clinical studies are needed in order to clarify the relationship between attention deficits, reading problems and motor coordination difficulties, to search for underlying causes of these comorbidities, and to evaluate the consequences of these commonly co-existing problems at the functional levels of activity and participation. This should also include studies of seemingly pure cases of developmental disorders, which should be carefully compared to children with concomitant difficulties within a multidisciplinary perspective. The application of qualitative methodology, including in-depth analyses of the children's own experiences, holds the possibility of adding important information with respect to clinical daily-life consequences of co-existing and pure types of developmental disorders.

In order to provide adequate intervention for children with developmental problems and disorders, the results from study IV and V point to a basic multidisciplinary perspective as

valuable and necessary. The findings in study IV indicate that a participatory multidisciplinary on-site intervention approach provides opportunities for diffusion of good practice and competence between different groups of professionals. Increasing teacher competence stood out as particularly important in order to facilitate individual and structural environmental changes, which in turn facilitated physical activity and motor development and learning for children with motor coordination difficulties and associated conditions. In study V long-term effects of two different types of motor intervention for children with DCD at the age of 6 were evaluated. The results point to a school-based, high-intensity, task specific approach as superior to a general group motor skills approach, the latter so far traditionally applied by Norwegian municipal physiotherapists. Parental reports particularly highlighted stable and positive long-term effects of the task specific approach at the functional levels of activity and participation. However, at follow-up children from both groups still presented as socially vulnerable, with a high rate of co-existing attention deficits and learning difficulties.

There is a strong need for further clinical studies in order to compare and evaluate different types of intervention approaches and programmes. Knowledge concerning long-term effects is particularly lacking. Research is needed on how to develop and match intervention programmes specifically to each child's individual developmental and activity profiles and to the child's learning potential and preferred learning styles. Further research on how to enhance environmental and organizational factors that promote motor development and learning is also needed.

There is still much work to be done with regard to providing sufficient clinical services for children with developmental problems and disorders. Multidisciplinary services need to be available and coordinated, during the diagnostic processes as well as when intervention is planned and implemented. Municipal health and educational resources in Norway are limited. But if well organized and spent, they can make an important positive difference in the lives of the children and families involved, which is the ultimate goal for clinicians as well as researchers.

5. References

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